WELL DRILLING APPARATUS AND METHOD

FIELD OF THE INVENTION

The invention relates to improving well drilling rates by using projectiles to fracture rock and drilling through the projectile fractured rock.

BACKGROUND OF THE INVENTION

Rotary drilling rock bits are commonly used to drill boreholes for oil wells, gas wells, geothermal wells, etc., especially where the terrain consists of soft to medium hard rock. Rotary drilling rock bits drill by essentially appplying point loads to the rock with a series of hardened knobs, cutters, protrusions or projections on rotatably mounted conical surfaces. The point loads are of sufficient magnitude to comminute the rock by fracturing, shearing and the like.

In deep drilling, such as to depths greater than about 5,000 feet, high strength igneous rock is frequently encountered. Such rock may effectively reduce or altogether stop the drilling because it has a higher hardness than most other commonly encountered rock formations. When the drill bit's cutting surfaces rapidly wear and its penetration rate decreases from increased rock hardness, the drill must be pulled from the hole to change to bits which provide harder cutting surfaces, such as tungsten carbide or possibly diamond bits. Such required bit changes cause an appreciable amount of down-time and hence economic loss to drilling investors.

Future exploration and development of the energy and mineral resources in the United States and throughout the world will require a great amount of drilling. Much of this drilling will be at great depths and through formations of extremely hard rock. While state of the art drilling technology has been primarily confined to softer oil and gas bearing sedimentary formations, the cost of drilling even this relatively soft rock is expensive. Much future drilling, particularly geothermal drilling, will be in formations having very hard rocks. Therefore, future drilling using state of the art drills will be very time consuming and expensive because of the greater depth to be achieved and the harder rock to be encountered.

SUMMARY OF THE INVENTION

In accordance with the present invention, there is provided an apparatus and method for drilling through igneous rock and other hard materials. Penetrating or fracturing projectiles or shaped charges are impelled into the rock immediately below a conventional drill bit at various locations on the rock to be drilled relative to the path of the drill bit to fracture the rock and thereby render a drillable by conventional bit. Projectiles may be impelled one at a time, sequenced in any desired manner; they may be fired in several ways and may be of any selected type, two projectile embodiments being disclosed by way of example.

One object of the present invention is to decrease hard rock drilling costs.

Another object of the invention is to increase rock drilling rates.

Still another object of the instant invention is to fracture hard rock below conventional drill bits to reduce bit wear.

One advantage of the present invention is that in accordance therewith, down-time during drilling operations is substantially reduced.

Another advantage in practicing the present invention is that drill bit life is lengthened.

Still another advantage of the present invention is that the need for expensive diamond bits when drilling through hard rock is lessened.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects and advantages of the present invention will be apparent to those skilled in the art from the following description with reference to the appended drawings, wherein like numbers denote like parts, and wherein:

FIG. **1** is a perspective view of a preferred embodiment of the invention;

FIG. **2** graphically illustrates the comparative hardness of several types of rocks;

FIG. **3***a* is a partially cutaway view of an exemplary embodiment of a shaped charge projectile in accordance with the invention;

FIG. **3***b* illustrates the rear portion of the projectile of FIG. **3***a* as the projectile is deployed and activated;

FIG. **3***c* shows another exemplary embodiment of a projectile suitable for use in practicing the invention;

FIG. **4** graphically compares drilling rates practicing the invention with prior art rock bit drilling rates;

FIG. **5** is a bottom end plan view partially drawn in phantom showing barrel placement in a two rotation cutter, two-barrel embodiment of the invention;

FIG. **6** is a partially cross-sectional and partially elevation cutaway view along lines **6—6** of FIG. **5**;

FIG. **6***a* shows the joint between bit body **31** and structural member **100**;

FIG. **6***b* shows the mud gates in open position;

FIG. **7** is a partially cross-sectional and partially elevation view of the revolver along lines **7—7** of FIG. **6**;

FIG. **8** illustrates the revolver of FIG. **7** in position to receive projectiles from the magazines;

FIG. **9** is a partially plan and partially cross-sectional view of the revolver's gate closing mechanism in closed position along lines **9—9** of FIG. **6**; and

FIG. **10** illustrates the revolver's gate closing mechanism of FIG. **9** in the open position.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT OF THE INVENTION

Drilling at accelerated rates through hard formations such as igneous rock formations is accomplished in accordance with the invention by impelling shaped charges, penetrators, projectiles or the like to fracture, shear, break and/or penetrate a rock formation followed by drilling with a rock drill through the fractured formation until the drill bit has penetrated a predetermined distance, or until the drill is not advancing satisfactorily. At such time additional projectiles are used to gain fracture the rock below the drill bit. These steps may be repeated as desired to accomplish rock or other fracturable hard formation drilling. Too, both projectile impelling and rock drilling may be performed concurrently.

In FIG. **1**, an apparatus **10** in accordance with the invention may be employed for drilling through hard rock formations within a borehole having wall **12**. Apparatus **10** may be rotated on a drill "string" or stem **14** in order to better accomplish rock grinding, fracturing or hole sizing with a bit **32**. Drill stem **14** connects at its